531 Rec'd PCT 22 JUN 2001

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED / ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		ATTORNEY'S DOCKET NUMBER P66761US0 US APPLICATION NO (If known, see 37 CFR 1.5) 09/857205
INTERNATIONAL APPLICATION NO PCT/KR00/01192	INTERNATIONAL FILING DATE 21 October 2000	PRIORITY DATE CLAIMED 26 OCTOBER 1999
TITLE OF INVENTION APPARATUS AND METHOD FOR CONTROLLING A POWER OF REVERSE LINK IN CDMA SYSTEM		
APPLICANT(S) FOR DO/EO/US Dong Do LEE, Sang Yun LEE and Byung Moo KIM		

Applicant herein submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information.

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☐ A proper Demand for Internatl. Preliminary Examination was made by the 19th month from earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A translation of the annexes to the Internatl. Preliminary Examination report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☒ An assignment document for recording. A separate cover sheet compliance with 37 CFR 3.28 and 3.31 is included.
13. ☐ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information:
    International Search Report
    PCT Request Form
    PCT/IB/308 Form
    First Page of Publication

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US APPLICATION NO (If known, see 37 CFR 1 5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
09/857206	PCT/KR00/01192	P66761US0

	CALCULATIONS	PTO USE ONLY
17. ☒ The following fees are submitted: **Basic National Fee (37 CFR 1.492(a)(1)-(5)):** Internatl. prelim. examination fee paid to USPTO (37 CFR 1.492 (a) (1)) .. $690.00 No international preliminary examination fee paid to USPTO (37 CFR 1.492 (a) (2)) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) .. $710.00 Neither international preliminary examination fee (37 CFR 1.492 (a) (3)) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO) .... **$1000.00** International preliminary examination fee paid to USPTO (37 CFR 1.492 (a) (4)) and all claims satisfied provisions of PCT Article 33(2)-(4) .... $100.00 Search Report prepared by the EPO or JPO (37 CFR 1.492 (a) (5)) .... **$860.00** **ENTER APPROPRIATE BASIC FEE AMOUNT =**	$ 1000.00	
Surcharge of $130.00 for furnishing the **oath or declaration** later than ☐ **20** ☐ **30** months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

Claims	Number Filed	Number Extra	Rate		
Total Claims	**8** - 20 =	-0-	x $18.00	$	
Independent Claims	**3** - 3 =	-0-	x $80.00	$	
Multiple Dependent Claim(s) (if applicable)			+ $270.00	$	
TOTAL OF ABOVE CALCULATIONS =				$ 1000.00	
Reduction by 1/2 for filing by **small entity**, if applicable. Verified Small Entity statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28).				$	
SUBTOTAL =				$ 1000.00	
Processing fee of $130 for furnishing the **English translation** later than ☐ **20** ☐ **30** months from the earliest claimed priority date (37 CFR 1.492(f))				$	
TOTAL NATIONAL FEE =				$ 1000.00	
Fee of $40.00 for recording the enclosed **assignment** (37 CFR 1.21(h)). Assignment must be accompanied by appropriate cover sheet (37 CFR 3.28, 3.31).				$ 40.00	
TOTAL FEES ENCLOSED =				$ 1040.00	
				Amt. to be refunded:	$
				Amt. charged:	$

a. ☒ A check in the amount of $ 1040.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. **06-1358** in the amount of $ ___ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge my account any additional fees set forth in §1.492 during the pendency of this application, or credit any overpayment to Deposit Account No. **06-1358**. A duplicate copy of this sheet is enclosed.

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JPH&S 3/95

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DESCRIPTION

APPARATUS AND METHOD FOR CONTROLLING A POWER OF REVERSE LINK IN CDMA SYSTEM

1. Technical Field

The present invention relates to a method of controlling uplink (reverse link) power level in a code division multiple access (CDMA) communication system.

2. Background Art

In a conventional method conducting a closed-loop power control for a reverse link, a signal power from a mobile station (MS) is estimated at a base station (BTS), the estimated power is then compared with critical power magnitude required for maintaining signal quality. According to the comparison result, the BTS transmits a TPC (Transmit Power Control) bit for commanding the MS to increase or decrease current transmitting power level of a MS. Receiving the TPC bit, the MS interprets it and increments or decrements the transmitting power level stepwise. The power level adjusting resolution is 1.0dB.

FIG. 1 illustrates a functional block diagram of a power controlling unit installed in a mobile station.

A MS receives downlink (forwad link) signals from a neighboring BTS, then, an automatic gain controller (AGC) 11 adjusts its gain to flatten the received signal level, a demodulator 12 extracts the TPC bit from the received downlink signals, a TPC interpreter 13 interprets which operation the extracted TPC bit is requesting. A power level controller 15 determines whether to increment or decrement

closed-loop power level by the adjusting step P_{closed} based on the interpretation, and adds the determined $\pm P_{closed}$ to an open-loop power control level ΔP_{open}, which is determined by a RSSI 14 based on the level of the output signal of the AGC 11. A power adjusting signal for the total power control level ΔP_t ($=\Delta_{Popen} \pm P_{closed}$) is applied to a high-power amplifier (HPA) 16 from the power level controller 15 so that the current power level of uplink signals is adjusted by ΔP_t.

The power level of signals transmitted from a MS is estimated every 1.25 msec at a BTS. The time 1.25 msec is equal to duration of 6 Walsh symbols and is called a power control group (PCG). Therefore, sixteen power control groups are contained in a 20msec-long traffic frame.

A BTS transmits 1-bit TPC command to a MS based on the estimated power level every PCG. Thus, the power level controller 15 of a MS outputs the 1dB power increment signal to the HPA 16 if the value interpreted every 1.25 msec is '1', and it outputs 1dB power decrement signal if '0'.

However, the 1-bit TPC information is frequently distorted due to wireless environment, and if a receiving power level changes very rapidly or slowly (a power level changing speed is mainly affected by the moving speed of a MS), it is difficult to track the variation of the power level through the only 1dB increment or decrement.

For example, supposed that power level received at a BTS is the graph of P_{Rx} as shown in FIG. 2, it is ideal that the transmitting signal power level controlled by the power level controller 15 is the graph of P_{Tx}. However, 1dB step ($\triangle P$) adjustment conducted every 1.25 msec can not track the graph P_{Tx} exactly as shown in FIG. 2 when the variation of power level to compensate is too sharp since the moving speed

of a MS is very high. In addition, when the variation of power level is too small, 1dB-step adjustment may cause an oscillation of transmitting power level.

3. Disclosure of Invention

It is an object of the present invention to provide an uplink power level controlling method of adjusting power control step size based on the moving speed of a mobile station in CDMA communication system.

It is another object of the present invention to provide an uplink power level controlling method of checking the reliability of power control command received from a BTS, and adjusting the transmitting power level based on the checked reliability.

The closed-loop uplink power controlling apparatus according to the present invention comprises: a channel estimator detecting power or phase of a specific channel of received downlink signals; a speed estimator estimating a moving speed of the mobile station based on the detected power or phase; a step adjuster changing the size of a power control step based on the estimated moving speed; a demodulator extracting a power control command contained in the received downlink signals; and a power level controller adjusting power level of transmitting signals by the changed power control step size according to the extracted power control command.

The closed-loop uplink power controlling method according to the present invention, receives downlink signals, detects power or phase of a specific channel of the received downlink signals, extracts power control command from the received downlink signals, estimates a moving speed of a mobile station based on the detected power or phase, measures the reliability of the extracted power control command, changes a power control step size based on the estimated moving speed,

and increases or decreases power level of transmitting signals by the changed power control step size according to the extracted power control command and its measured reliability.

This uplink power controlling method according to the present invention can optimize uplink transmitting power and prevent the quality of uplink signals from being degraded due to errors in transmitting power control information delivered from a BTS to a MS, thereby reducing power consumption of a MS, improving the quality of an uplink signal, and increasing the number of MSs admittable to a BTS.

4. Brief Description of Drawings

The accompanying drawings, which are included to provide a further understanding of the invention, illustrate the preferred embodiment of this invention, and together with the description, serve to explain the principles of the present invention.

In the drawings:

FIG. 1 illustrates a functional block diagram of a power controlling unit installed in a mobile station;

FIG. 2 is exemplary curves showing receiving power of a BTS and transmitting power of a MS controlled according to the power control command;

FIG. 3 illustrates a block diagram of a closed-loop power controlling unit according to the present invention; and

FIG. 4 is a flow diagram embodying an uplink closed-loop power level controlling method according to the present invention.

5. Modes for Carrying out the Invention

The accompanying drawings illustrate the preferred embodiments of the present invention, and together with the description, serve to explain the principles of the present invention.

FIG. 3 illustrates a block diagram of a closed-loop power controlling unit of a MS according to the present invention.

This power controlling unit of FIG. 3 comprises an AGC 31 flattening the level of downlink signals received from a neighboring BTS; a channel estimator 23 detecting magnitude and/or phase of pilot channel of output signals from the AGC 31; a speed estimator 33 estimating a moving speed of a MS based on the detected magnitude and phase of pilot channel; a step adjuster 34 adjusting a power controlling step size (△P) based on the estimated moving speed; a demodulator 35 extracting TPC bits from the level-flattened downlink signals from the AGC 31; a TPC verifier 36 measuring how much reliable the extracted TPC bits are; a power level controller 37 outputting a power control signal commanding to increment or decrement current transmitting power level by the adjusted step size (△P) according to the TPC bits whose reliability is measured by the TPC verifier 36; and a HPA 39 power-amplifying uplink signals, which has been modulated through a modulator 38, according to the power control signal.

The estimated moving speed of a MS is closely correlated with the slope of power level graph , for example, the graph P_{Rx} in FIG. 2, of uplink signals received at a BTS.

FIG. 4 is a flow diagram embodying an uplink closed-loop power level controlling method according to the present invention. This flow diagram conducted in the power controlling unit configured as FIG. 3 is explained in detail.

Downlink signals from a neighboring BTS is received at a MS, the AGC 31 flattens the average level of the received signals through adjusting its gain, and applies the level-flattened signals to the channel estimator 32 and the demodulator 35 at the same time (S1). The channel estimator

32 detects power magnitude and/or phase of the pilot channel of the downlink signals. The demodulator 35 demodulates the received downlink signals and extracts power control information, that is, TPC bit from the demodulated signals (S2).

The speed estimator 33 estimates the moving speed of a MS based on the detected power magnitude and/or phase of pilot channel. This estimating method is explained later.

The TPC verifier 36 measures the reliability of the extracted TPC bit in consideration of the history of TPC bits and the energy of the just-received TPC bit (S3). For example, the rules that the more recently a TPC bit was received, the larger a weighting factor used for the TPC bit is, and that the reliability is proportional to the energy magnitude detected within the just-received TPC bit may be used to measure the reliability. Considering such rules, a reliability measuring equation is derived as follows.

$$reliability(W) = \frac{\sum^{N} a_i TPC_i}{N} W_1 + E_{TPC} W_2$$

where weighting factor condition of $a_i > a_{i+1}$ should be satisfied since smaller i means nearer time to the present, N is the number of data sampled within a TPC bit, E_{TPC} is energy magnitude detected at a just-received TPC bit, and W_1 and W_2 are ratios to reflect how much the reliability is affected by the TPC history and the energy of the latest TPC bit, respectively. It is preferable that the condition of $W_1<W_2$ is satisfied.

The reliability measured according the above equation is used as a weighting factor for power controlling step size.

The step adjuster 34 determines and sets the power controlling step size ($\triangle$P) based on the estimated moving speed (S4). The step size is chosen within a range from 0.1dB

to 2dB. In this determination, the step size is chosen to or over 1dB to track the power variation quickly if the estimated moving speed is high, and it is chosen to or below 0.25dB to track the power variation slowly, if the moving speed is low or zero. If the speed is moderate, 0.5dB step is selected. This step size adjustment is conducted every 1.25 msec.

To simplify the step adjusting circuit, it is preferable that the adjustable step sizes are fixed to 0.25dB, 0.5dB, and 1dB.

Then, the power level controller 37 controls the HPA 39 such that the transmitting power of the HPA 39 is adjusted based on the step size set by the step adjuster 34 and the measured reliability (S5). That is, the transmitting power is increased as much as the set step size multiplied by the measured reliability, if the received TPC bit is '1', and it is decreased that much, if '0'.

The equations used for the above-explained power level control process are explained.

The speed estimator 33 calculates the level crossing rate (LCR) and average fade time (AFT) from the detected power magnitude of a pilot channel based on the following equations:

LCR = $n(\gamma - A)$ = N/T, where A is reference level, and N is # of crossings over T - second length; and

AFT = $i(r-A) = \frac{\sum_{i=0}^{N} t_i}{N}$ where t_i is individual fade.

After these two values of LCR and AFT are obtained, a corresponding moving speed is picked out from a pre-specified table indicative of speed versus LCR and AFT. This table is derived from experiments and theoretical feature

that each of LCR and AFT is proportional to a moving speed of a MS.

The detected phase may be used to estimate the moving speed instead of the detected magnitude since the speed of phase variation is proportional to the moving speed of a MS, too.

If such moving speed estimation is done at the speed estimator 33, the step adjuster 34 determines the power control step size ($\triangle P$) corresponding to the picked moving speed. Then, the power level controller 37 calculates adjustment magnitude P_{ADJ} using the equation of $P_{ADJ} = TPC \times W \times N \times \triangle P$, where TPC is sign of TPC bit(± 1), W is measured reliability, N is min(C, $\triangle Pmax/\triangle P$) where C is the number of TPC bits indicative of power changes in the same direction, and $\triangle Pmax$ is maximum step size.

After the adjustment magnitude P_{ADJ} is calculated, the power level controller 37 controls transmitting power of the HPA 39 to decrease or increase according to the equation of: next power level(P_n) = current power level (P_{n-1}) + P_{ADJ}.

CLAIMS

1. An apparatus of controlling uplink transmitting power in a CDMA mobile station, comprising:

a channel estimator detecting power magnitude and/or phase of a specific channel of received downlink signals;

a speed estimator estimating a moving speed of the mobile station based on the detected power magnitude and/or phase;

a step adjuster changing the size of a power control step based on the estimated moving speed;

a demodulator extracting a power control command contained in the received downlink signals; and

a power level controller adjusting power level of transmitting signals by the changed power control step size according to the extracted power control command.

2. The apparatus set forth in claim 1, wherein said specific channel is pilot channel.

3. The apparatus set forth in claim 1, further comprising a measuring means measuring the reliability of the extracted power control command, wherein said power level controller derives a weighting factor from the measured reliability, multiplies the changed power control step size by the derived weighting factor, and increments or decrements the power level of transmitting signals by the multiplied step size.

4. The apparatus set forth in claim 3, wherein said measuring means measures the reliability based on the energy magnitude of the extracted power control command and history of power control commands.

5. The apparatus set forth in claim 3, wherein the magnitude (P_{ADJ}) of power level adjusting step is determined by the equation of $P_{ADJ} = TPC \times W \times N \times \triangle P$, where TPC is sign of

TPC bit($\pm$1), W is measured reliability, N is min(C, $\triangle$Pmax/$\triangle$P) where C is the number of TPC bits indicative of power changes in the same direction, $\triangle$P is the changed power control step size, and $\triangle$Pmax is maximum step size.

6. A method of controlling uplink transmitting power in a CDMA communication system, comprising the steps of:

(a) receiving downlink signals;

(b) detecting power magnitude and/or phase of a specific channel of the received downlink signals, and extracting power control command from the received downlink signals;

(c) estimating a moving speed of a mobile station based on the detected power magnitude and/or phase;

(d) changing a power control step size based on the estimated moving speed; and

(e) increasing or decreasing power level of transmitting signals by the changed power control step size according to the extracted power control command.

7. The method set forth in claim 6, wherein said step (d) conducts the step changing operation every 1.25 msec.

8. A method of controlling uplink transmitting power in a CDMA communication system, comprising the steps of:

(a) receiving downlink signals;

(b) extracting power control command from the received downlink signals;

(c) calculating the reliability of the extracted power control command;

(d) deriving a weighting factor from the calculated reliability and multiplying a determined power control step size by the derived weighting factor; and

(e) increasing or decreasing power level of transmitting signals by the multiplied power control step size according to the extracted power control command.

FIG. 1

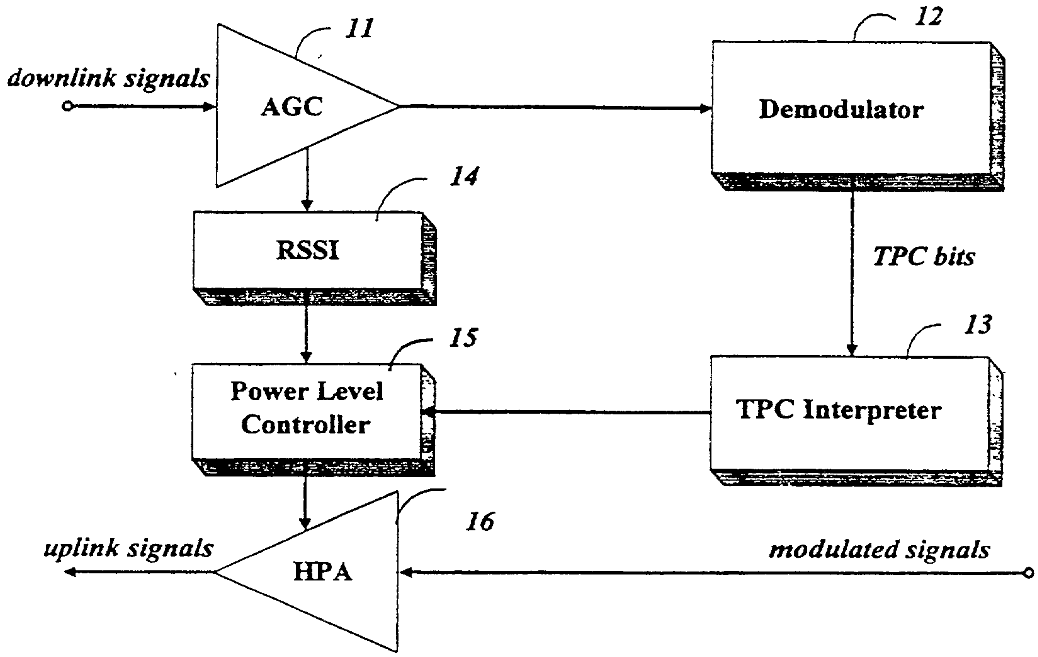

11
12
downlink signals
AGC
Demodulator
14
RSSI
TPC bits
15
13
Power Level Controller
TPC Interpreter
16
uplink signals
HPA
modulated signals

FIG. 2

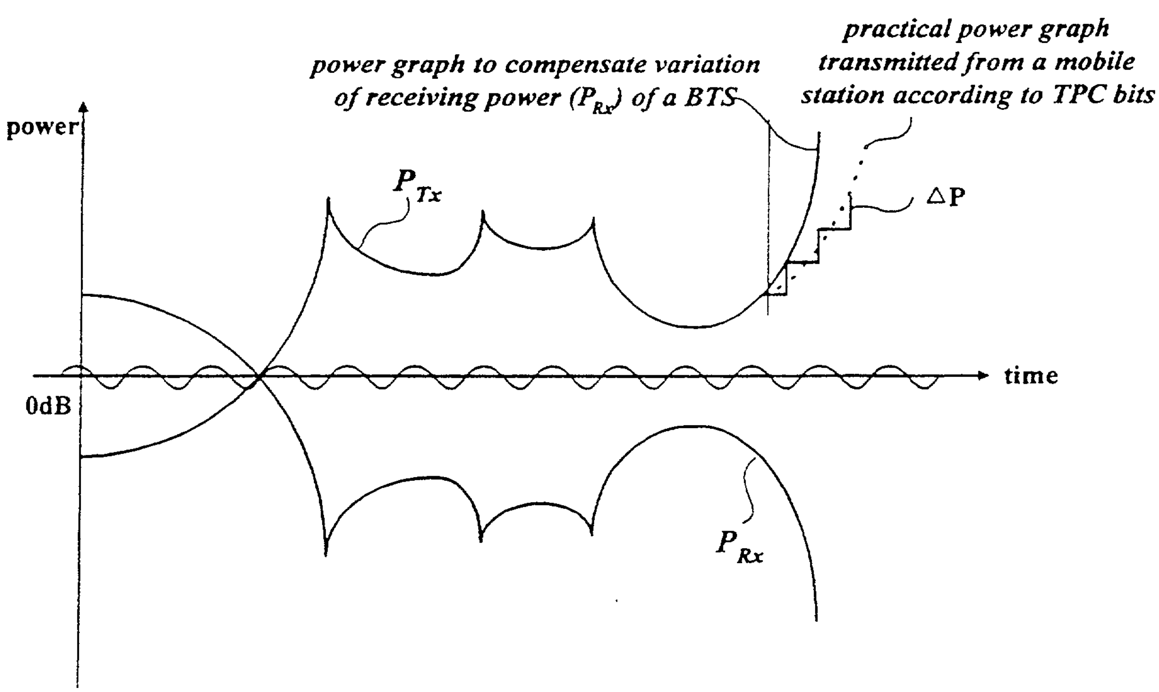

practical power graph transmitted from a mobile station according to TPC bits
power graph to compensate variation of receiving power (P_{Rx}) of a BTS
power
P_{Tx}
ΔP
time
0dB
P_{Rx}

FIG. 3

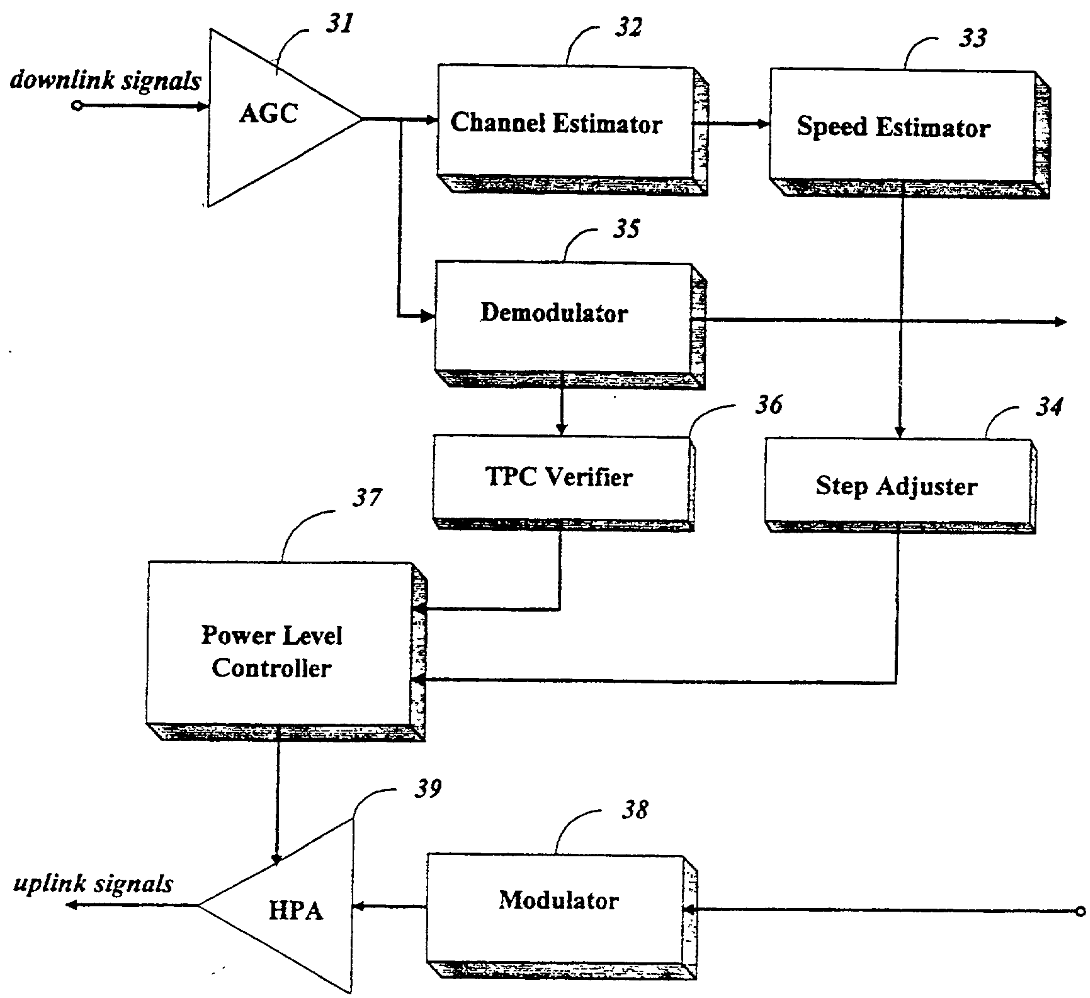
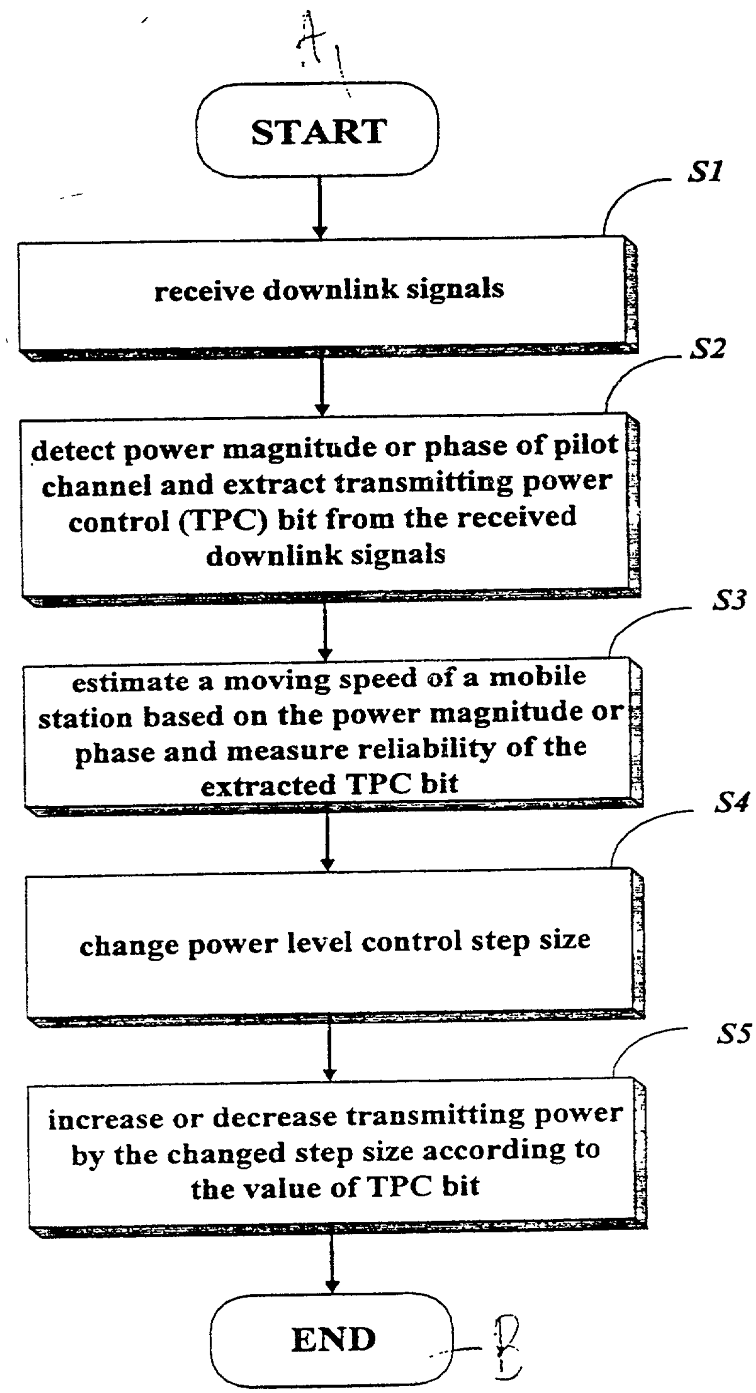

31
32
33
downlink signals
AGC
Channel Estimator
Speed Estimator
35
Demodulator
36
34
TPC Verifier
Step Adjuster
37
Power Level Controller
39
38
uplink signals
HPA
Modulator

FIG. 4


A
START
S1
receive downlink signals
S2
detect power magnitude or phase of pilot channel and extract transmitting power control (TPC) bit from the received downlink signals
S3
estimate a moving speed of a mobile station based on the power magnitude or phase and measure reliability of the extracted TPC bit
S4
change power level control step size
S5
increase or decrease transmitting power by the changed step size according to the value of TPC bit
END
B

DECLARATION AND POWER OF ATTORNEY U.S.A.

ALL PATENTS, INCLUDING DESIGN
FOR APPLICATION BASED ON PCT; PARIS CONVENTION;
NON PRIORITY; OR PROVISIONAL APPLICATIONS

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ATTORNEYS' DOCKET NO

As a below named inventor, I declare that my residence, post office address and citizenship are stated below next to my name, the information given herein is true, that I believe that I am the original, first and sole inventor (if only one name is listed at 201 below), or an original, first and joint inventor (if plural inventors are named below at 201-203, or on additional sheets attached hereto) of the subject matter which is claimed and for which patent is sought on the invention entitled:

101 102 APPARATUS AND METHOD FOR CONTROLLING A POWER OF REVERSE LINK IN CDMA SYSTEM

which is described and claimed in: ☐ PCT International Application No. ______ filed ______

☐ the attached specification ☐ the specification in application Serial No. ______ filed ______

(if applicable) and amended on ______

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.
I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.
I hereby claim foreign priority benefits under Title 35, United States Code, §119 (a)-(d) of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

103 Prior Foreign Application(s)

(Number)	(Country)	(Day/Month/Year Filed)	Priority Claimed Yes	No
99-46523	Republic of Korea	26/10/1999	☒	☐
PCT/KR00/01192	PCT	21/10/2000	☒	☐
			☐	☐

104 I hereby claim the benefit under Title 35, United States Code,§119(e) of any United States provisional application(s) listed below:

Application No. ______ Filing Date ______ Application No. ______ Filing Date ______

105 I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial No.) (Filing Date) (Status: patented, pending, abandoned)

POWER OF ATTORNEY* As a named inventor, I hereby appoint the following attorneys (Registration No.) to prosecute this application, receive and act on instructions from my agent, and transact all business in the Patent and Trademark Office connected therewith. HARVEY B. JACOBSON, JR. (20,851); D. DOUGLAS PRICE (24,514), JOHN CLARKE HOLMAN (22,769); MARVIN R. STERN (20,640); ALLEN S. MELSER (27,215), MICHAEL R. SLOBASKY (28,421); JONATHAN L. SCHERER (29,851); IRWIN M. AISENBERG (19,007); WILLIAM E. PLAYER (31,409); YOON S. HAM (45,307) and NATHANIEL A. HUMPHRIES (22,772)

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*Inventor(s) name must include at least one unabbreviated first or middle name.

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	POST OFFICE ADDRESS	POST OFFICE ADDRESS 109-802,Saetbyul Apt.,Bundang-dong,Bundang-gu,Seongnam	CITY Kyunggi-do	STATE OR COUNTRY Korea		ZIP CODE 463-030
203	FULL NAME* OF INVENTOR	FAMILY NAME KIM	GIVEN NAME Byung Moo		MIDDLE NAME	
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	POST OFFICE ADDRESS	POST OFFICE ADDRESS 115-707,Saemmaeul,Hogye-dong, Dongan-gu, Anyang	CITY Kyunggi-do	STATE OR COUNTRY Korea		ZIP CODE 431-080

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both, under section 1001 of Title 18 of the United States Code; and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

SIGNATURE OF INVENTOR 201*	SIGNATURE OF INVENTOR 202*	SIGNATURE OF INVENTOR 203*
Lee Dong Do	Lee Sang Yun	Kim Byung Moo
DATE 8. June 2001	DATE 7. June 2001	DATE June 7, 2001

☐ Additional inventors are named on separately numbered sheets attached hereto.